Using Software Capability Evaluations to Reduce Software Development Risk

Brian Gallagher, Software Engineering Institute
Bonnie Troup, The Aerospace Corporation

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Acknowledgment

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Outline

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Software Acquisition State of the Practice

- **Virtually all large-scale software-intensive systems suffer from difficulties in achieving cost, schedule, and performance objectives.**

- **In spite of this, the demand for complex software-intensive systems continues to increase, both in the Government and commercial arenas.**

- **Most of the problems in software development can be attributed to poor management practices, not technical difficulties.**

Guidance From DoD 5000.2-R

- ***"The acquisition strategy shall include identification of the risk areas of the program and a discussion of how the PM intends to manage those risks."*** **(para 3.3.3)**

- ***"Software shall be managed and engineered using best processes and practices that are known to reduce cost, schedule, and performance risks."*** **(para 4.3.5)**

- **Software capability evaluations are identified as an acquisition "best practice". (para 3.3.5.2)**

Mitigating Software Risk

- **Risk is reduced by selecting a contractor with mature software engineering processes.**
  - The quality of a software system is largely governed by the quality of the process used to develop and maintain it.

- **Two methods are used during competitive source selections to evaluate an offerer's process capability**
  - The Software Engineering Institute's Software Capability Evaluation (SCE[SM]) technique uses the Capability Maturity Model[SM] for Software (SW-CMM®) as the basis for findings.
  - The Software Development Capability Evaluation (SDCE) is a systematic method, developed by AFMC for use in source selection, for evaluating a contractor's capability to execute a software-intensive project.

[SM] Capability Maturity Model and SCE are service marks of Carnegie Mellon University.
® Capability Maturity Modelling and CMM are registered in the U.S. Patent and Trademark Office.

Outline

❶ Problem and Background

→ ❷ The Software Capability Evaluation (SCE)

❸ The Software Development Capability Evaluation (SDCE)

❹ Evaluation Processes Compared

❺ Benefits

SCE History

- **Developed to support source selection in major government software acquisitions**
  - Originally documented in *A Method for Assessing the Software Engineering Capability of Contractors* (Humphrey, 1987)
  - Publicly baselined in Software Capability Evaluation Version 1.5 Method Description (SEI, 1993)
  - Major activities of interviewing and document review remain relatively unchanged from the original
  - Currently baselined in Software Capability Evaluation Version 3.0 Method Description (SEI, 1996)

SCE Overview

- **Uses the Capability Maturity Model℠ for software (SW-CMM®) as a basis for findings**
  - Separate entity from the SCE process
  - Documented in *The Capability Maturity Model - Guidelines for Improving the Software Process,* CMU/SEI, Addison-Wesley, 1995

- **A "maturity questionnaire," based on the CMM, is used to prepare for mandatory site visits**
  - Questionnaire requires "yes/no" answers
  - "Yes" responses require elaboration detailing amount of implementation and the mechanism or documentation justifying the response
  - Site visit - NOT evaluation of questionnaire responses - is primary evaluation activity

℠ Capability Maturity Model is a service mark of Carnegie Mellon University.
® Capability Maturity Model and CMM are registered in the U.S. Patent and Trademark Office.

The CMM for Software*

Level	Focus	Key Process Areas
5 Optimizing	Continuous process improvement	Defect Prevention Technology Change Management Process Change Management
4 Managed	Quantitative management	Quantitative Process Management Software Quality Management
3 Defined	Process standardization	Organizational Process Focus Organization Process Definition Training Program Integrated Software Management Software Product Engineering Intergroup Coordination Peer Reviews
2 Repeatable	Basic project management	Requirements Management Software Project Planning Software Project Tracking & Oversight Software Subcontract Management Software Quality Assurance Software Configuration Management
1 Initial	Competent people and heroics	

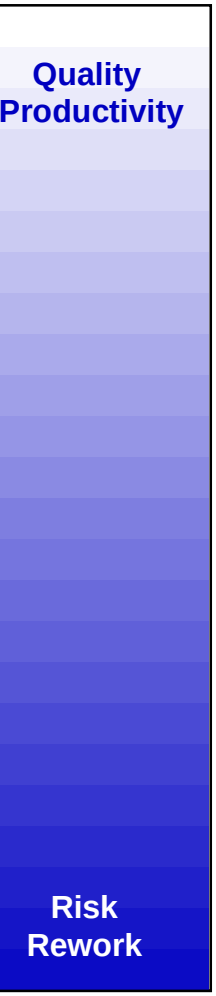


*chart courtesy of the SEI

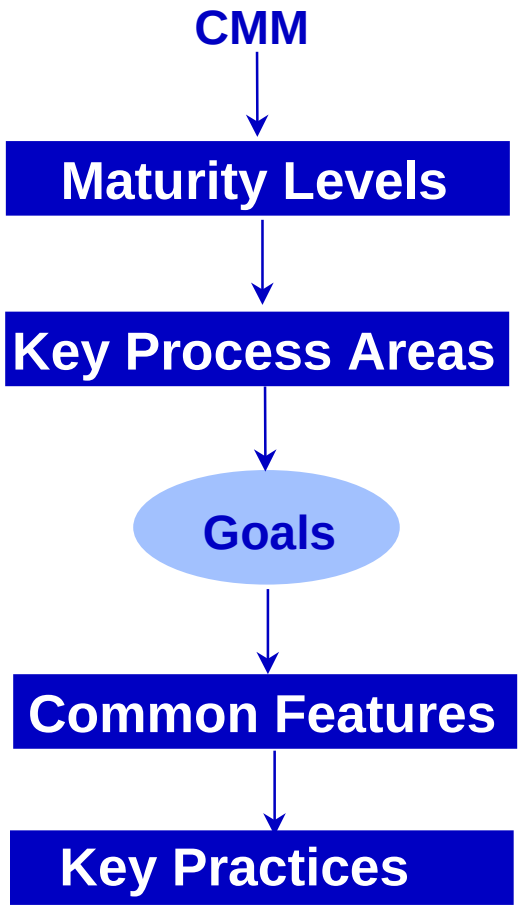
The SCE Process

- Select and train the SCE team
- Define scope of evaluation
- Define processes
- Develop interview scripts
- Select projects for evaluation
- Analyze contractors' Maturity Questionnaires
- Incorporate into RFP

- Collect data on-site for 3 existing projects
  - Document review
  - Interviews
  - Presentations
- Consolidate data
- Develop findings against the SW-CMM
- Determine strengths, weaknesses, risks, and improvement activities

- Develop report for the SCE sponsor organization
- Present the results to the SCE sponsor
- Conduct feedback to the contractors (optional)

CMM Tailoring for SCEs



DEPTH-ORIENTED SCE TAILORING

- **Select** RELEVANT KPAs
- **Evaluate** ALL goals, common features, and key practices for selected KPAs
- **Maturity level rating not possible**

BREADTH-ORIENTED SCE TAILORING

- **Select** ALL KPAs within chosen maturity levels
- **Evaluate** RELEVANT goals, common features, and key practices
- **May determine a maturity level rating**

COMBINED SCE TAILORING

- **Select** RELEVANT KPAs
- **Evaluate** RELEVANT goals, common features, and key practices
- **Maturity level rating not possible**

Tailoring the SCE Model

- **Tailoring guidelines exist**
  - Consistency and ability to compare SCEs and their results is a key principle
- **Model tailoring**
  - Can restrict breadth of model evaluated and perform depth-oriented SCE
  - Can restrict depth of model evaluated and perform breadth-oriented SCE
  - Can restrict both breadth and depth of model evaluated
  - Can add to the SCE model, e.g., a KPA or an activity
- **Process tailoring**
  - Can constrain numbers of projects and site visit participants
  - Can tailor process in some other ways, if risk documented and accepted

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SDCE History

- **Developed by an AFMC Process Action Team (PAT) with industry and FFRDC participation (1993)**
  - —Developed for use in source selection
  - —Participants from Aeronautical Systems Center (ASC), SMC, Electronics Systems Center (ESC), Aerospace, SEI, MITRE, Institute for Defense Analysis (IDA), and contractor organizations (Lockheed, Martin-Marietta, Westinghouse, Hughes, etc.)

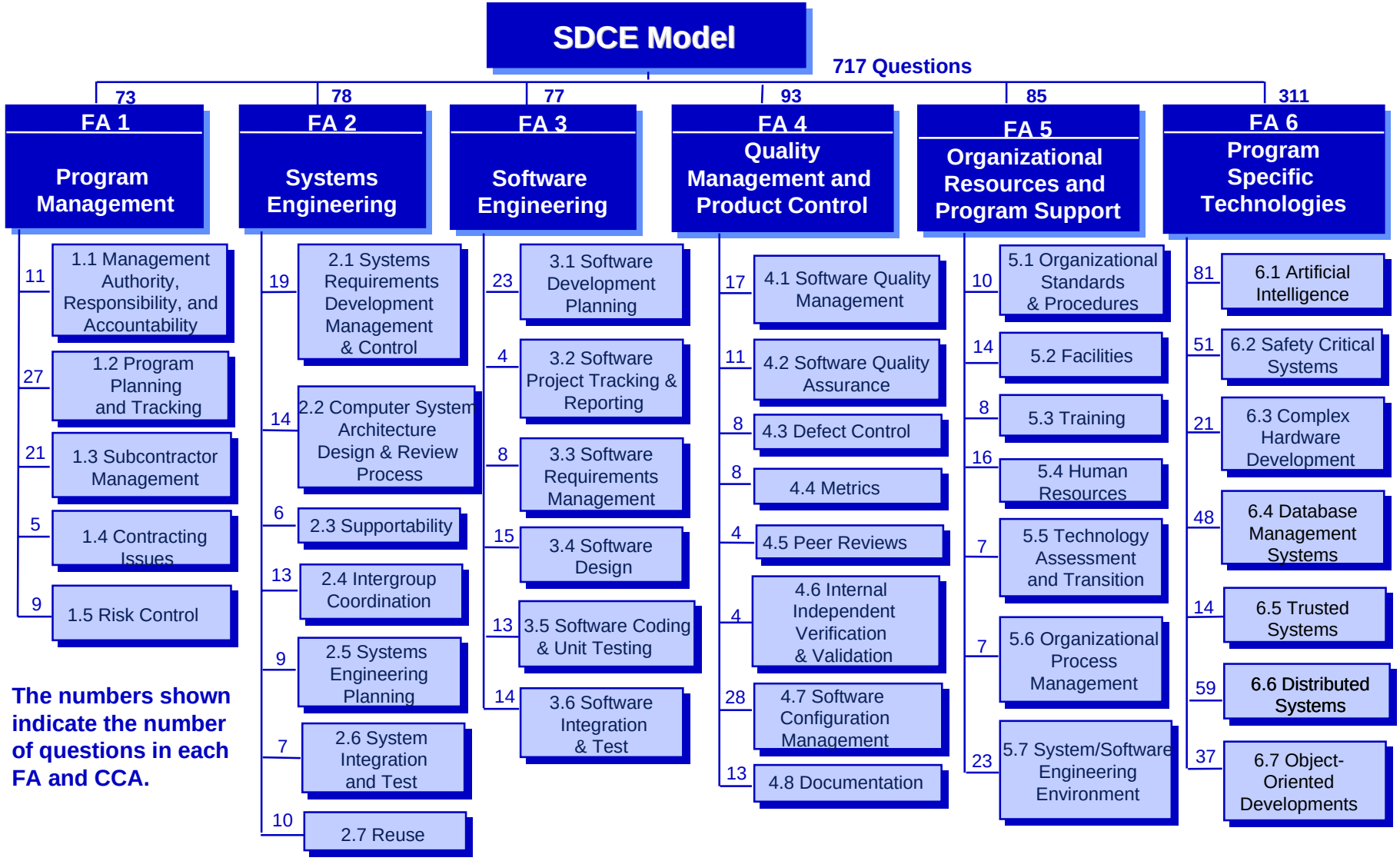
- **Based on two precursor methods**
  - —Software Development Capability/Capacity Review (SDC/CR) developed by Aeronautical Systems Center (1983)
  - —Software Capability Evaluation (SCE), based on the Capability Maturity Model (CMM) developed by the Software Engineering Institute (1987)

SDCE Overview

- **Scope**
  - Software and systems engineering processes
  - Software and systems management processes
  - Special technologies (e.g., safety-critical systems, trusted systems, distributed systems, object-oriented development, artificial intelligence)
- **Philosophy**
  - Reduce risk by selecting a contractor with proven plans, processes, methods and tools
  - Use SDCE to evaluate offerors in proposed approach (processes, methods, tools), commitment to following proposed approach, and past experience with proposed approach

Basic SDCE Model—Top Level

Reducing Software Risk



The numbers shown indicate the number of questions in each FA and CCA.

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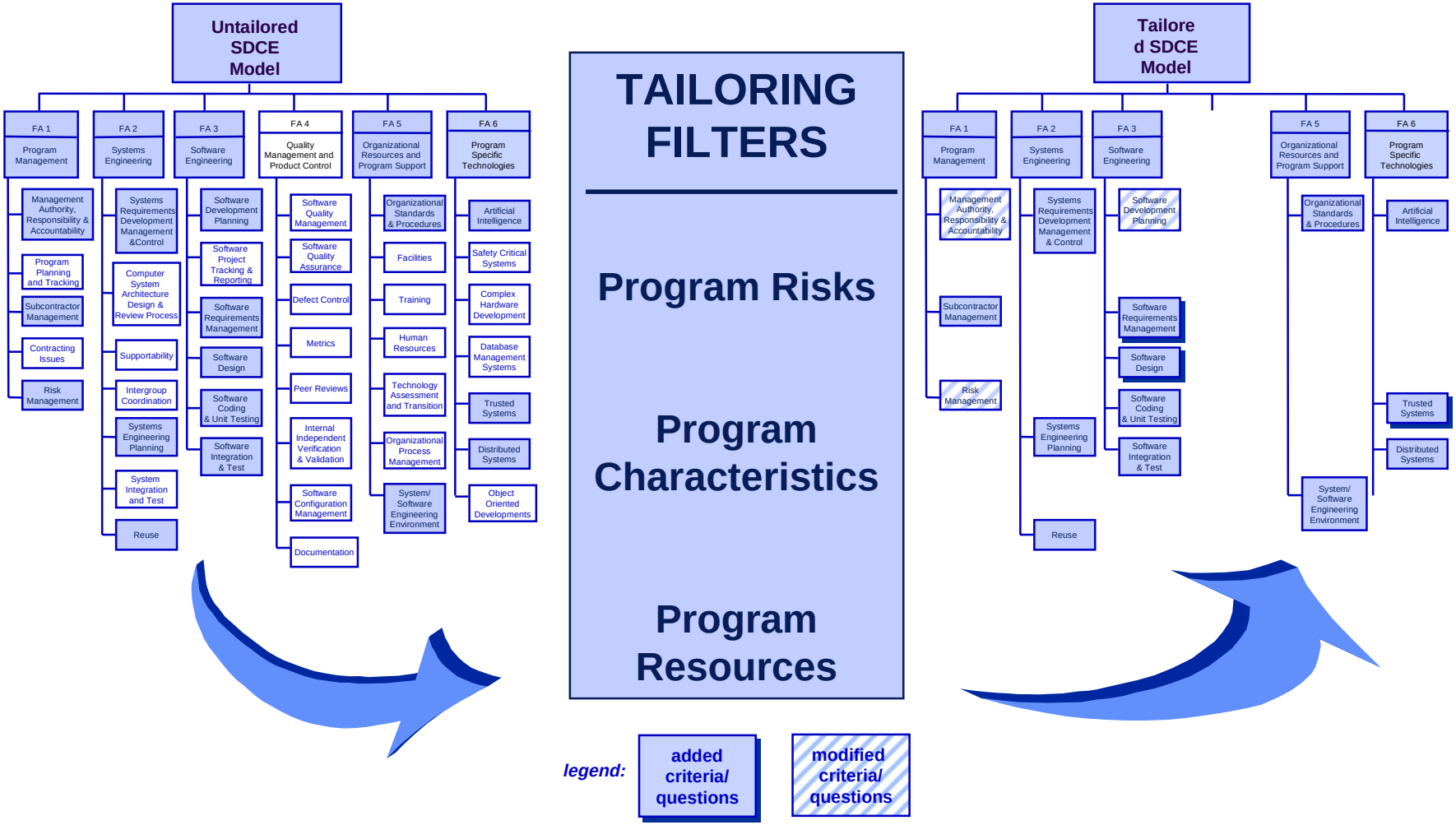
The SDCE Process

- **Determine program risks and resources**
- **Define processes**
- **Prepare plan & schedule**
- **Tailor SDCE (determine questions and criteria)**
- **Select & prepare team**
- **Incorporate into RFP**

- **Review proposals/offeror responses to questionnaire**
- **Prepare ENs**
- **Perform site visits (optional) to confirm/ clarify responses**
- **Analyze EN responses**
- **Establish SDCE results (determine strengths, weaknesses, risks)**
- **Integrate with source selection**

- **Transition SDCE results**
- **Conduct feedback (optional)**
- **Program follow-through**

Tailoring the SDCE Model



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Model Tailoring Objectives

- **Strengthen SDCE usefulness to specific application**
  - Focus questions and criteria on program risks
  - Discriminant in source selection
- **Enhance SDCE applicability to specific programs**
  - Concentrate on key management and technical concerns
  - Examples from recent applications include
    - Integrated Product Teams (IPTs) and intergroup coordination
    - Reuse/re-engineering
    - Requirements management
    - Management of incremental development
    - Commercial-Off-The-Shelf (COTS) use
- **Support acquisition reform**
  - Avoid detailed questions that lead to specific processes or methods

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SDCE and SCE Similarities

- **Both SDCE and SCE**
  - Gather information using a defined model
  - Use evidence from recent projects to establish capability
  - Produce results in terms of strengths, weaknesses and risks
  - Have a defined process for integrating into source selection
    - SCE: Software Capability Evaluation Version 3.0, *Implementation Guide for Supplier Selection*, CMU/SEI-95-TR-012, April 1996
    - SDCE: *Acquisition Software Development Capability Evaluation Vols. 1 and 2*, Air Force Material Command Pamphlet (AFMCPAM) 63-103, 15 June 1994

SDCE and SCE Differences

- **SCE**
  - Designed to evaluate software process of an ***organization*** to gain insight into its process capability
  - Establishes the existence and use of processes, but does not evaluate the quality of the processes
  - Site visits mandatory: used to ***establish*** findings on topic areas identified from question responses, program risks, etc.
- **SDCE**
  - Designed to evaluate an offeror's capability to execute a specific software-intensive ***project***
  - Establishes the existence, use and quality of processes
  - Site visits optional: used to ***confirm/clarify*** findings from question responses
  - SDCE model covers several technology areas
  - SDCE model covers other areas in more detail than SCE (e.g., facilities and engineering environments)

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Benefits to the Program Offices

- **Increases:**
  - Likelihood of selecting a software-capable contractor
  - Likelihood of obtaining a strong contractual commitment
  - Visibility of software as a key risk item
  - Understanding of the importance of software
  - Information on the contractor's proposed software development processes
  - Ability to perform more focused contract monitoring

Aerospace Evaluation Experience

- **SCEs completed for SMC/NRO**
  - Brilliant Eyes, SMTS, Future Imaging Architecture

- **SDCEs completed for SMC**
  - DMSP's STT, Milstar's Comm Management, DMSP CDFSII, GPS OCS support, RSA Phase II, GPS Block IIF, AFSCN RCDC, AFSCN NOUC, AFSCN CCSC, SBIRS High, Classified, AirBorne Laser, EELV Pre-EMD, GBS, EELV EMD

Aerospace Potential SDCEs for FY 99 - 00

- AFSCN SLRS
- AFSCN Sustainment and Development
- GPS DAGR
- NPOESS
- SBIRS Low

Summary

Selecting a mature software developer reduces risk by increasing the probability of delivering systems within cost, schedule, and performance objectives.

The SCE and SDCE have both been used successfully to evaluate the maturity of a developer's software processes during source selection, and thus, to reduce post-contract award software risk.

Resources

- **The Aerospace Corporation**
  - Software Acquisition and Analysis Department
    - Bonnie Troup (310)336-1334, bonnie.r.troup@aero.org
    - Sharon Hoting (310)336-2909, sharon.k.hoting@aero.org
- **The Software Engineering Institute**
  - Brian Gallagher (412) 268-7157, bg@sei.cmu.edu

Back-up Slides

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SCE

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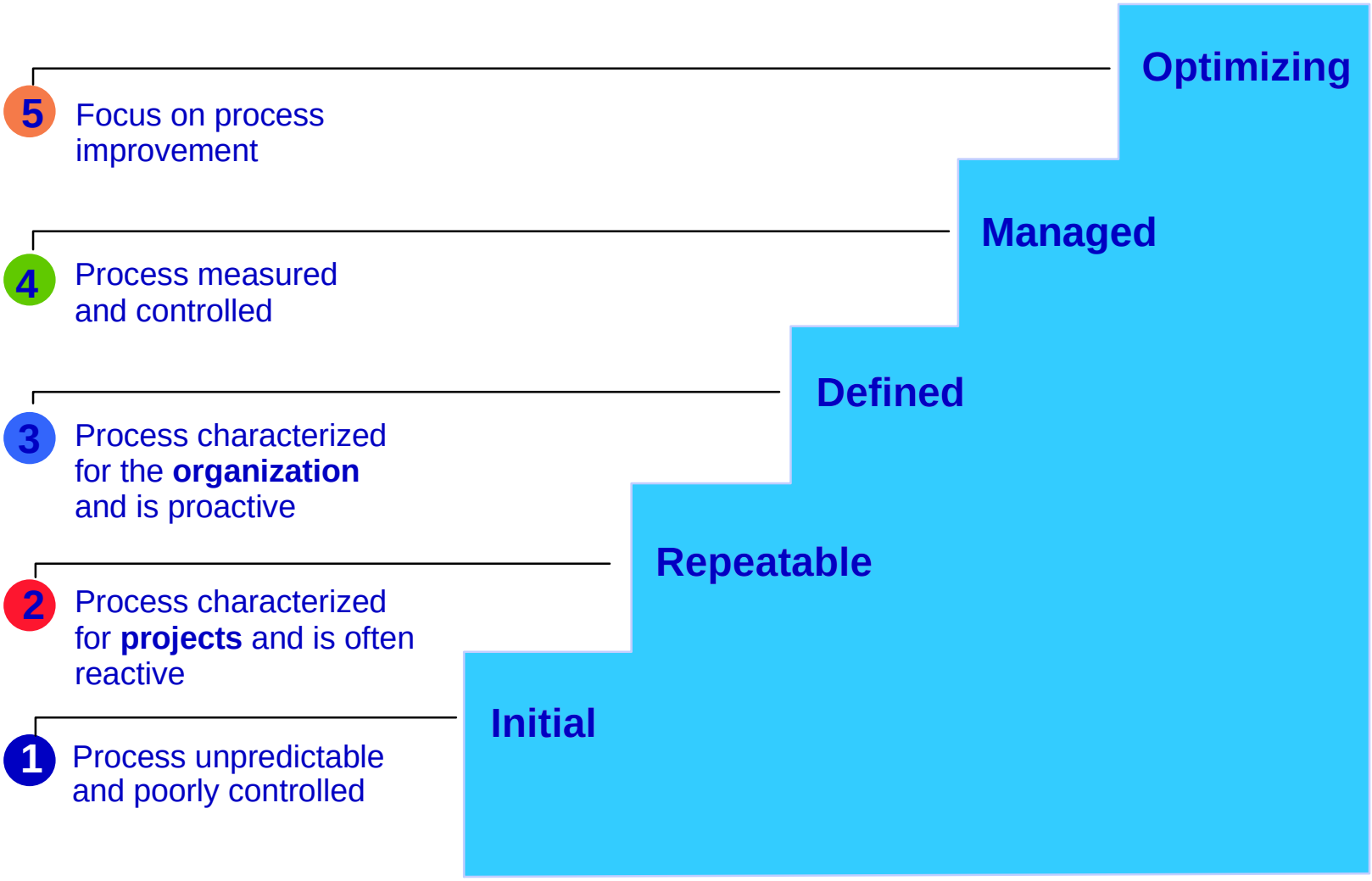
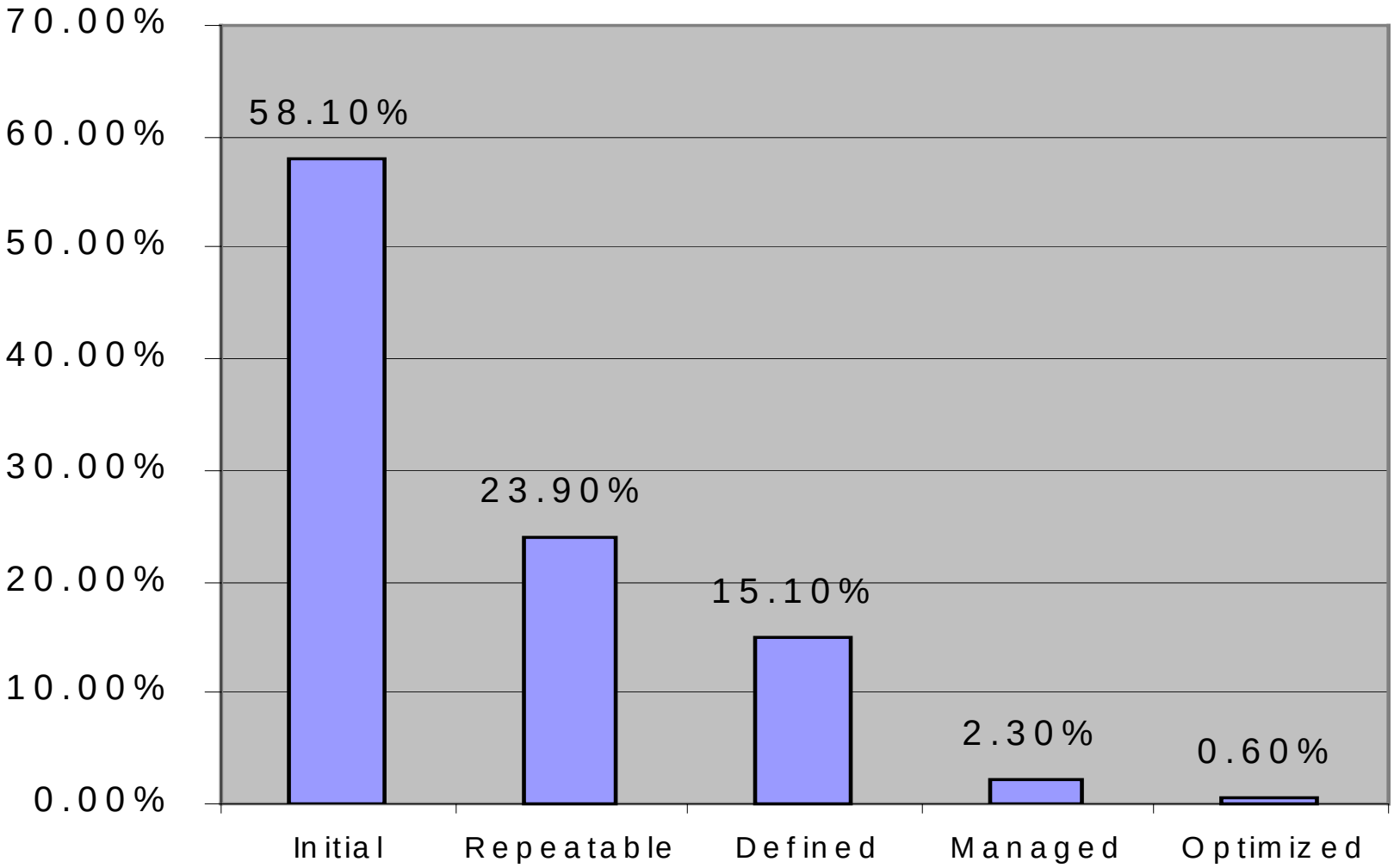
The Maturity Levels



Organization Maturity Profile

Most Recent Assessment (SEI May 98)



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An Example - Peer Reviews KPA

A Level 3 KPA

Purpose: ***to remove defects from the software work products early and efficiently*****.**

Involves examination of work products by the producer's peers to identify defects and areas where changes are needed.

Goals

1 Peer reviews are planned.

2 Defects in the software work products are identified and removed.

Peer Reviews KPA - 2

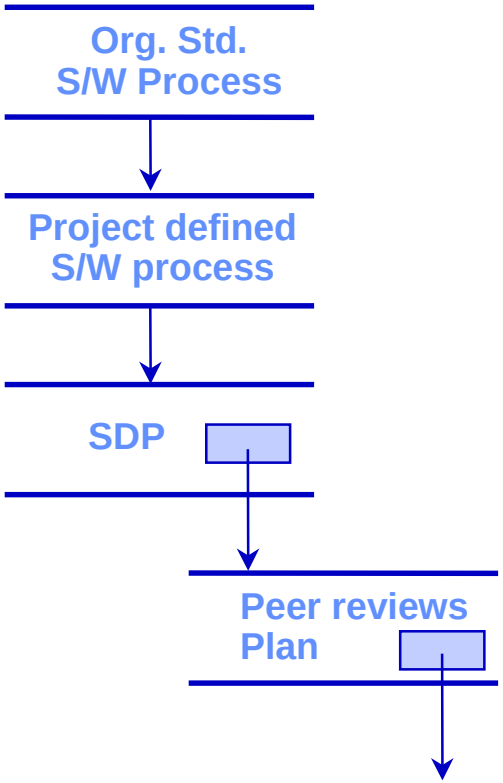
What are work products?

- source code
- test plans
- analysis artifacts
- design artifacts
- others?

Commitment and ability

- There's an organizational policy for performing peer reviews.
- Adequate funding and resources are provided.
- Leaders and participants receive training.

Peer Reviews KPA - 3



Activity 1: ***Peer reviews are planned and the plans are documented***

Schedule
– leader names
– reviewer names

Pictographs based on: Dymond, Kenneth *A Guide to the CMM: Understanding the Capability Maturity Model for Software.* Annapolos, Maryland: Process Transition International, Inc.

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Peer Reviews - 4

Procedure

Review materials in advance; adequate prep time

Readiness Completion

Criteria

Checklists

Action Items Tracked to closure

Peer Review Data

– what product
– size and composition of review team
– review parameters (prep time, length of review)
– number and type of defects found and fixed

Activity 2: *Peer reviews performed according to a documented procedure*

Activity 3: *Data on the conduct and results of peer reviews are recorded*

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Peer Reviews KPA - 5

Measurement and analysis

— Measure the process to determine the status of peer review activities.

Verification

— Software QA reviews and/or audits the activities.

Sample SCE Findings

"Data from peer reviews are collected and results are tracked to determine trends."

"Action items from peer reviews are not tracked to completion."

"Participants in peer reviews do not receive training in the conduct of the reviews."

"Work products subject to peer reviews are not selected according to a documented procedure."

Findings are fed into the source selection as "strengths" and "weaknesses."

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Level 2 and 3 Common Feature Summary

	KPA	Goals	Comm.	Abil.	Act.	Meas.	Verif.
Level 2	Reqs Mgmt	2	1	4	3	1	3
	SW Proj Planning	3	2	4	15	1	3
	SW Trk & Ovrsght	3	2	5	13	1	3
	SW Subcontrc Mgmt	4	2	3	13	1	3
	SW QA	4	1	4	8	1	3
	SW CM	4	1	5	10	1	4
Level 3	Org Prc Focus	3	3	4	7	1	1
	Org Prc Focus	2	1	2	6	1	1
	Trning Prog	3	1	3	6	1	3
	Int SW Mgmt	2	1	3	11	1	3
	SW Prod Eng	2	1	4	10	2	3
	Intergrp Coord	3	1	5	7	1	3
	Peer Reviews	2	1	3	3	1	1
	TOTALS	37	18	49	112	14	34

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SDCE

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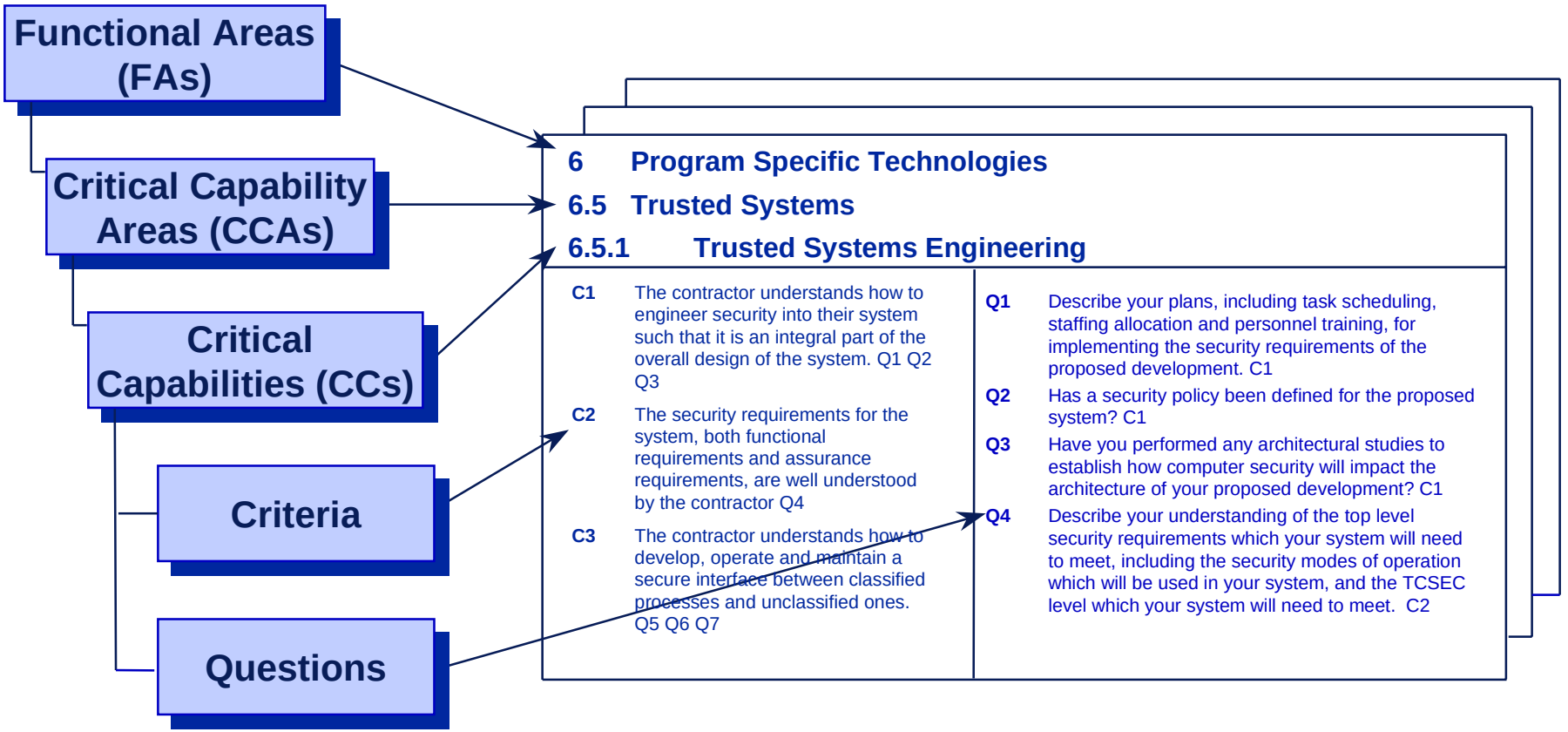
Hierarchical Structure of the SDCE Model



SDCE Process Phases and Activities

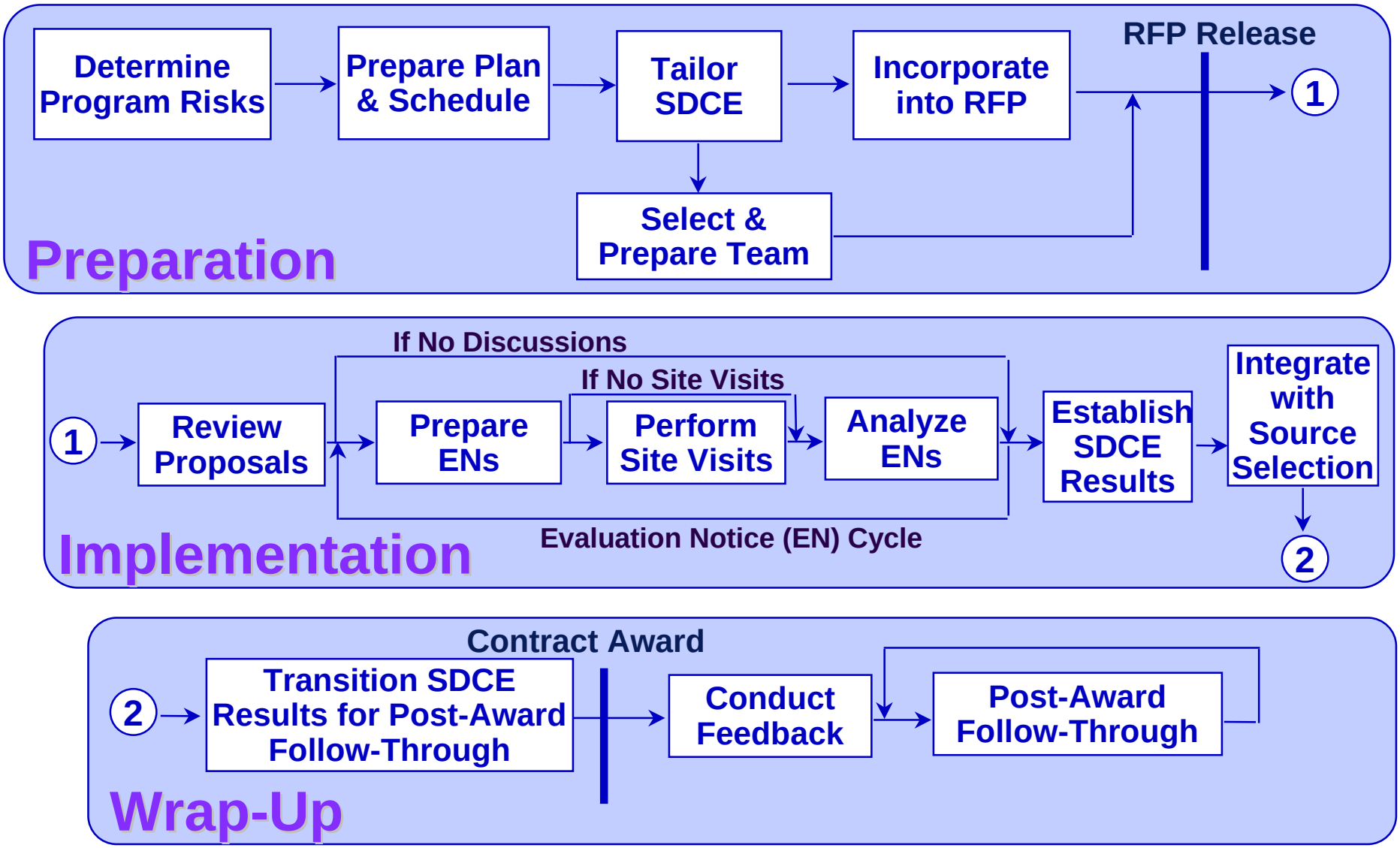
- **Determination of Applicability**
  - Program Size
  - Number of Offerors
  - Position in DoD Lifecycle

- **SDCE Phase 1: Preparation Phase**

- **SDCE Phase 2: Implementation Phase**

- **SDCE Phase 3: Wrap-Up Phase**

SDCE Process Flow



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SDCE Preparation Steps

- **Determine Program Risks**
  - Develop Evaluation Standards
  - Identify risks to be considered in SDCE model tailoring
- **Prepare Plan & Schedule**
  - Identify all preparation and implementation activities
  - Determine position of SDCE in source selection structure
  - Estimate size and scope of questionnaire
  - Develop preliminary schedule
- **Tailor SDCE Model and Process**
  - Focus on program risks
  - Refine plan and schedule as needed

SDCE Preparation Steps (cont.)

- **Incorporate into RFP**
  - Prepare RFP
    - Instructions to offerors' responses in sub-section L-2
    - Evaluation Factors under section M
    - SDCE questionnaire and criteria (may be an appendix)
  - Brief the offerors on the tailoring and SDCE implementation process
- **Select & Prepare Team**
  - Base selection on software engineering, domain, and special technology expertise
    - Level of expertise of team members can make or break the SDCE effort!
  - Brief team on tailoring and SDCE implementation process

SDCE Implementation Steps

- **Review Proposals**
  - Perform initial proposal review
    - Review and evaluate SDCE responses
    - Check consistency with other material in the proposal
- **If Discussions**
  - Prepare and release Evaluation Notices (ENs) to offerors
  - If site visits, prepare for and hold site visits
    - Focus on EN responses and confirmation of contractor processes
    - Ensure that offeror participants include representatives of the software organization(s) under evaluation
  - Analyze EN Responses

SDCE Implementation Steps (cont.)

- **Establish SDCE Results**
  - Trace findings to questions/criteria and to responses
- **Integrate SDCE results into source selection evaluation**
  - Determine strengths, weaknesses, and risks with respect to evaluation criteria, based on SDCE results
  - Recommend degree of severity of weaknesses and risks (*, **, ***) and level of strengths (+, ++, +++)
  - Participate in rolling up strengths, weaknesses, and risks to subfactor and factor levels

SDCE Wrap-Up Steps

- **Transition SDCE Results**
  - For post-award follow through
    - Identify risks to be monitored throughout contract
    - Determine and document process for doing so
  - To assist in planning and implementing future SDCEs
    - Record characteristics of SDCE
    - Record SDCE team “lessons learned”
- **Conduct Feedback (optional)**
  - Present findings to evaluated offeror(s) after contract award
  - Do not share findings for one contractor with the other contractor at any time
- **Post-Award Follow Through**
  - Apply results, as permissible, for timely start on risk management